ology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——.

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Arctowski, Henryk. Studies on climate and crops. p. 745–760.

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Machatschek, Fr[itz]. Zum Klima von Turkestan. p. 449–454.

Türstig, R. Verdunstung auf dem Nil bei Khartum. p. 454–462.

Hann, J[ulius] v. Der tägliche Gang der Windstärke auf dem Gipfel des Ben Nevis und seine Bedeutung für die Theorie. p. 462–470.

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NOTE ON CLIMATOLOGICAL AVERAGES.

It has always been very difficult to clearly demonstrate either changes or agreements as to the climatic conditions of different localities, or of different periods and principally because of a want of homogeniety in the lengths of the periods or the faithfulness of the respective records of temperature, rainfall, cloudiness, etc. If the exposures of the instruments, the hours of observation, and the years of record are homogenous, and the individual observers themselves are not changed, then we may confidently hope that the resultant climatic averages will be strictly comparable.

Climates are the results of the action of meteorological influences for many years, and must be defined as the average for long periods of years. So many years must be considered in taking such averages that the addition of as many more years will not appreciably alter the figures. Thus, if 50.4° F. is the average temperature for the period 1750 to 1800, with an inherent reliability of plus or minus 0.3° depending upon the agreement of the 50 individual years among themselves, and if in a corresponding way we get 50.5° F. plus or minus 0.3° F. for the average of 1800 to 1850, and again get 50.6° F. plus or minus 0.3° F. for the average from 1850 to 1900, then we have 50.5° F. for the average of the whole three periods with a reliability of plus or minus 0.2° F. The reliability increases slowly with the length of record, unless we happen upon a 50-year period in which unusual extremes of temperature have occurred. Such unusual extremes force one to feel that the climate is more variable than usually thought and that averages are not quite so reliable as hoped for.

The reliability of an average or normal temperature, for instance, always depends upon two important factors; (1) the actual variations of temperature from year to year and, (2) the number of years taken into consideration. In order to find the "index of reliability" we simply compare the average for the 50 or 150 years with each individual annual figure; tabulate all the differences; take the average of these latter, regardless of the plus or minus signs, and multiply it by the proper factor in the following table. The result is the reliability of the average of all the years of record. These factors are quoted from page 25 of the last edition of Dr. Hann's Handbook of Climatology, but are probably given in many treatises on the "theory of probabilities" or "the laws of chance" or "the method of least squares."

Years of record.	Factor.
20	0.191
25	0.171
30	0.156
35	0.144
40	0.134
50	0.120
60	0.109
80	0.095
100	0.085

In the above example, the mean of each successive 50 years was 50.4° F., 50.5° F., and 50.6° F., respectively. These averages seem to run along progressively, increasing as though the temperature of the region were steadily growing higher, a peculiarity that often happens to thermometers and to exposures without belonging to the climate proper. But in this case as both thermometers and exposures were often checked against the standard and were properly corrected, we may assume that our averages belong to the atmospheric temperature itself and that the air was a little warmer during the last period than during the first. But we are seeking for the temperature of the climate unaffected by the variations from year to year. Now, variations of many degrees cause irregularities of a few tenths in the averages, such that we say the figure 50.4° F. is uncertain by plus or minus 0.3° F. as compared with what we may expect to get when we have enough years of record at our disposal. In other words, we expect that the long-time average will be somewhere between 50.1° F. and 50.7° F. So also with the other 50-year periods; the second period justifies us in expecting the true climatic average to lie between 50.2° F. and 50.8° F.; the last period gives us the range 50.3° F. to 50.9° F. These three ranges overlap each other so perfectly that we have no right to say that we have proved a change of temperature in these 150 years. We can only say that the change, if any, has been so slight that it is covered up by the ordinary irregularities and that the proper thing is to say there has not been a demonstrable change in temperature. On the other hand, we can combine all three periods together and say that we have proved that the average temperature for 150 years is 50.5° F., with a reliability of plus or minus 0.2° F.; or that the probable average temperature for a very long period such as 500 years will lie between 50.3° F. and 50.7° F., unless some unusually cold or warm periods should occur. These did not occur between 1750 and 1900, and these records give us no reason to think that they will occur.

The longer we make these records of temperature, so much the more likely are they to include therein a few extraordinary years, and one or two centuries is long enough to embrace a few.

Some climatic tables show in detail the exact number of departures from a long-time average, arranged in the order of size; thus for Vienna, whose average for the month of January during the 20 years 1881–1900 is minus 2.2° C., we have the following departures:

Departure:	Cases.
0° to +1°	3
0° to −1°	4
+1° to +4°	4
−1° to −4°	5
Above +4°	2
Below −4°	2
Total	20

This little tabular illustration for January shows a slight predominance of the number of cases of departure toward low temperature, or, in other words 11 departures on the negative side of the average counterbalance 9 departures on the positive side. This is another way of looking at the variability of January.

These illustrations are given in order to enforce the principle accepted in all sound studies of climatology, that climatic averages prove nothing unless they relate to the same years and that comparisons between different stations for different periods must be held subject to the query: What are the reliabilities of the respective averages?

When the periods at any two stations we may wish to compare embrace nearly the same years but are deficient in a few, then these deficiencies must be allowed for before a fair comparison can be made, so that the final averages to be compared shall as nearly as possible relate to some standard interval of time.

One method of reducing a short record of temperature to a 33-year record is given by Prof. Bigelow on page 656 of the Monthly Weather Review for 1910. A method of reducing rainfall records, which will also apply to other elements, is given on pages 205 to 243 of the Monthly Weather Review of April, 1902. On page 238 of that long article, Prof. Angot, now director of the Central Meteorological Bureau of Paris, states that his interpolations for isolated months or years missing from the records of rainfall are done by him according to the law first formulated by V. Fournie, Engineer of Roads and Bridges, in 1864.

In conclusion, averages prepared from "all available figures" do not of themselves "show conclusively" anything positive about local climates and their comparison with others, unless the respective data are thoroughly homogeneous as to quality and time.

Not only must crude averages be corrected for the missing years of record so as to include the same period at each station, but missing months must be allowed for, and especially must all relate to the same hours of observation. It is this laborious attention to details that gives the data published by Hann such a preeminent claim on our confidence.

C. A.